CONSERVATION INNOVATION GRANTS
Final Report

Grantee Name: University of Georgia	
Project Title: Demonstration of Variable-Rate Irrigation For Water Conservation And Application Optimization	
Project # NRCS 68-3A75-4-200	
University of Georgia Account # 2521 RF 324232	
Project Director: Calvin D. Perry	
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Period Covered by Report: 1 October 2004 – 30 Sept 2007	
Project End Date: 30 September 2007	

Project Background

Water conservation has become a critical issue in the southeast U.S. for many reasons including cyclical drought periods (some for extended periods), depleting aquifers, salt water intrusion near the coasts, and the "water wars" between Georgia, Florida and Alabama. These issues, coupled with urban sprawl, are increasing the political pressure for rural, agricultural regions to cut back on their water usage to meet the growing demand of these expanding affluent urban areas. The increasing urban demands are particularly hard hit for Georgia farms, where there are over 11,000 center pivot irrigation systems accounting for nearly 1.5 million acres of irrigation farm land (Harrison, 2005). Georgia's agricultural use of freshwater (irrigation) accounts for 18% of total use (Hutson et al., 2004), with 37% from surface water sources and 63% from groundwater (Harrison, 2005).

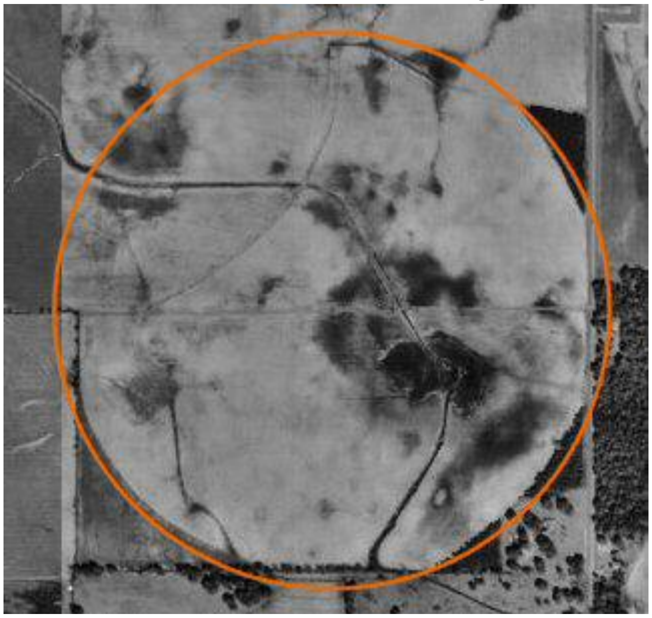

Figure 1. Aerial view of field showing variability.

Most center pivot irrigation systems currently in use apply a constant rate of water, yet very few fields are uniform. A field's inherently variable nature stems from factors such as soil type, topography, multiple crops, drainage ditches and waterways, and other non-cropped areas (Fig 1). To complicate matters most fields are irregularly shaped and some even have structures that may be in the pivot path, such as a house or barn. Thus, to optimize crop production and increase water use efficiency, a method is needed for delivering irrigation water in optimal, precise amounts over an entire field.

Over the past decade, many research groups in the U.S., including the University of Georgia-Tifton Campus, USDA/ARS in Florence, SC, and Ft. Collins, CO, University of Idaho, and Washington State University, have all developed different research systems for applying irrigation water in more precise amounts. Evans et al. (2000) and Sadler et al. (2000) provide excellent literature reviews of ongoing precision irrigation projects around the country, indicating a substantial interest in spatially-variable irrigation by researchers.

VARIABLE-RATE IRRIGATION SYSTEM

Beginning in 1999, the University of Georgia (UGA) Precision Ag team partnered with an Australian company, Farmscan (Computronics Corp. Ltd., Bentley, Western Australia), to develop a user-friendly and reliable/robust Variable-Rate Irrigation (VRI) control system for center pivot irrigation. The VRI system varies application amounts by cycling sprinklers ON/OFF (based on percent of 1 minute), controlling the end gun and by varying the system travel speed. Application rates are based on percent of "normal" application as selected by the center pivot operator by his/her choice of system travel speed. To reduce application in relation to "normal", the VRI system will increase system travel speed and/or cycle sprinklers. To increase application in relation to "normal", the system will decrease travel speed. For example, to achieve a 50% application rate, the VRI system either increases speed or signals a sprinkler control zone such that the sprinkler valves in that zone open for 30 sec and then close for 30 sec, repeating continuously. A rate of 80% would correspond to 48 sec ON and 12 sec OFF. A rate of 100% (the "normal" amount) is, again, set by travel speed of the pivot. Any rate over 100% would require slowing of the travel speed accordingly.

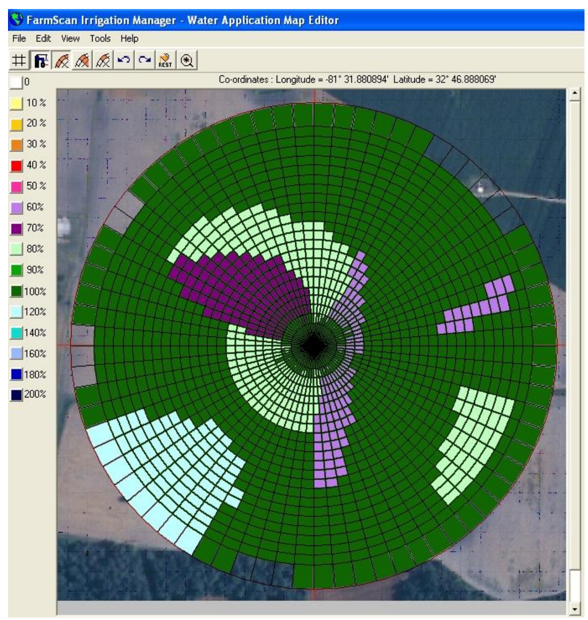

Figure 2. VRI map software.

The VRI system retrofits on existing center pivot systems and integrates GPS positioning to continuously determine location/angle of the mainline. The system is designed with several "failsafes" to insure the center pivot operator can apply water if there is an error or failure in the VRI system. Perry et al. (2002) describes the development of the UGA/Farmscan system in greater detail. The Farmscan Irrigation Manager PC software (Fig 2) provides for development of application maps. The software allows multiple pivots to be defined and allows each pivot to have multiple application maps defined.

Project Objectives

The objectives of the proposed project were:

1. Implement a VRI suitability index to identify VRI-suitable pivots (in Georgia and South Carolina);
2. Install VRI systems on 18 producer-owned center pivot (CP) systems (15 in Georgia, 3 in South Carolina) over 3 years;
3. Demonstrate the use, benefits and effectiveness of Variable-Rate Irrigation (VRI) for irrigation management, water conservation, and optimal application efficiency; and
4. Inform and educate stakeholders and policymakers as to how VRI systems can play a role in benefitting urban and rural communities.

Summarize the Work Performed During the Project

As outlined in our biannual reports, each year of the project we made significant progress on our grant deliverables. A brief outline of each and the status are listed below:

1. Development and implementation of VRI suitability index (attached) -- **100% Complete**.

2. Install 18 VRI control systems -- **100% Complete**.

   At the completion of the CIG project, all 18 VRI installations were completed – 13 in GA and 5 in SC. Project members also helped with software installation, application maps, provided aerial and digital orthoquad imagery, generated topographic and soil electrical conductivity (EC) maps, and other services where applicable.

3. Collect and analyze flow measurements, soil moisture, and runoff **-- 100% Complete**.

   Project members have collected soil moisture readings in various fields during the growing season(s). See attached final report for complimentary research project that accompanied this project. Flow assessments were made for each VRI system installed. Runoff observations have been made in the fields through 2007 growing season.

4. Host Regional Workshops on VRI technology **--100% Complete**.

   Project members have conducted a combination of 10 training sessions and field days which showcased the VRI technology. In addition, project members have also spoken at numerous professional meetings and county meetings explaining the technology and the cost-share opportunities available through the CIG grant.

5. Produce web-based and printed brochures on VRI technology **--100% Complete**.

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Grant Expenditures

Grant payments received:
As of the end of the project, $501,850 of the grant funds have been utilized (100% of funds).

Has there been a change of in-kind partners or contributions to the grant? If so, are there contributions with in the 25% of the 50% match of non-federal funds?
There were no changes and the regular and in-kind match was fully met.

Benefits or Results Expected and Transferability

Ag irrigators will potentially benefit from the installation of VRI on their center pivot irrigation systems (CP) in several ways. The local/regional environment will also see potential benefit from the use of VRI on CP systems – which impacts the good of society as a whole.

Irrigators

• potential to save water by not irrigating non-cropped areas
• potential to reduce pumping costs
• optimized water application where water is needed
• enhanced crop production / yields and quality
• becoming 'pro-active' in water management

Environment

• potentially less water pumped from critical surface and groundwater sources
• runoff reduced as water application is optimized for soil types/slope
• water not over-applied where adjacent pivots overlap
• helps preserve habitat for wildlife, fish, shellfish and other biota

Since the CP systems in use in Georgia are the same as pivots used throughout the U.S., benefits from this project are **directly transferable to other regions** of the U.S.

Environmental Impacts

The purpose of this project was to retrofit center pivot (CP) irrigation systems with VRI controls to optimally apply irrigation and conserve water. The VRI controls will allow the CP operator to vary the rate of application of water on different parts of fields with varying soil types, topography, and crop needs, including eliminating double application in overlap situations, thus more accurately and efficiently manage the cropping system being irrigated. The potential environmental impact of this project will be the reduction of water required for ag irrigation application.

Results and Conclusions

Grant Accomplishments—Products:

During the course of the grant, site visits for twenty-eight (28) CP systems (21 in GA, 7 in SC) were conducted and seven (18) VRI cost share systems were installed (13 in Georgia and 5 in South Carolina). There has also been a significant advancement in the amount of awareness of the VRI technology. VRI is now known nationally (for use on both row crops and dairy pivots). Major center pivot manufacturers are now offering their own versions for such technology.

Education and Outreach:

A paper brochure (Fig 5) explaining VRI and its applicability to dairy waste was printed and widely distributed.

Figure 3. Conducting center pivot site visit for VRI.

Field Days and Workshops that included discussion of VRI:
August 2005, Sumter County, GA. Over 30 attended.
January 2006, Terrell County and Pulaski County, GA. Over 100 attended.
April 2006, Calhoun County, GA. Over 100 attended.
August 2006, Poinsett County, AR. Over 200 attended.
September 2006, Barnwell County, SC. Over 100 attended.
February 2007, Seminole County, GA. 20 attended.
April 2007, Screven County, GA. 30 attended.
August 2007, Pulaski County, GA. 30 attended.
March 2008, Gordon County, GA. 30 attended.

In addition to these specific field days and workshops, the team took advantage of numerous opportunities to discuss VRI applicability to SE farming operations at professional meetings and at other events such as the Sunbelt Ag Expo.

Lessons Learned:

Some of the lessons learned from carrying out this CIG project for demonstration of Variable-Rate Irrigation for water conservation and application optimization:
• Farming operations are very cost sensitive.
• Water in the SE is free except for the pumping cost.
• The VRI technology is in its infancy and has occasional bugs / malfunctions.
• Most farmers are wary of cutting edge technology though some embrace it.
• Farmers are very dedicated to their profession.
• Default fail-safe mode must be to allow water application.
• Cost-share assistance critical to adoption of VRI technology.

Cost-Share

In accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

A. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;

   Jenny Crisp; S.S.# 254-76-0656

   Drake Perrow; Tax id # 57-0767527

   Bragg & Martin Williams (New Life Turf Farm); Tax id # 58-2296751

   Roger Nalls; S.S. # 254-70-9102

   Dargan Farm Partnership; Tax ID # 57-1092304

   James F. Taylor DBA Chokee Plantation; Tax ID # 20-2502281

   T&T Farms; Tax ID # 58-1185043

   Judd Hill Plantation; Tax ID # 71-6124924

   Magnolia Farm; Tax ID # 58-2478727

   Joe Boddiford Farms; Tax ID # 58-1231510

   Isbell Farm; Tax ID # 63-0317190

   W.P. Smith & Sons; Tax ID # 58-0983479

   Corrin F. Bowers & Son Farm; Tax ID # 57-0703451

   BTR Farms; Tax ID # 75-3106749

   The Tufgrass Group, Inc.; Tax ID # 58-2316573

   Sod Atlanta, Inc; Tax ID # 58-1606990

   North Georgia Turf, Inc; Tax ID # 58-1734888

B. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biennial and cumulative payment amounts must be submitted.

   Jenny Crisp: $11, 660.00

   Perrow: $ 10,528.00

   Williams: $ 9,754.00

   Roger Nalls: $24,517.13

   Dargan Farm Partnership: $10,281.13

   James F. Taylor DBA Chokee Plantation; $ 18,244.79

   T&T Farms; $ 15,978.83

   Judd Hill Plantation; $6,328.00

   Phillips; $ 13,816.00

Joe Boddiford Farms $12,984.00

Joe Boddiford Farms $8,010.00

Isbell Farm; $10,620.00

W.P. Smith & Sons; $11,836.00

Corrin F. Bowers & Son Farm; $11,516.00

BTF Farms; $12,188.00

The Turfgrass Group, Inc. $ 13,530

Sod Atlanta, Inc., $ 11,996

North Georgia Turf, Inc., $12,814.50

C. Self-certification statements indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill are available upon request.

Yes, we have self-certification statements for all installed systems. .

Variable Rate Irrigation (VRI) Suitability Index

To aid in determining if a particular center pivot irrigation system is a suitable candidate for fitting with VRI controls, an index using objective rating criteria would provide a convenient measure of such suitability.

University of Georgia scientists, in conjunction with USDA-NRCS personnel, developed a “VRI Suitability Index” (Table 1) to assist in rating (and ranking) center pivots being considered for cost-share assistance for the installation of VRI controls. The index included four required criteria (electric power supply, within geographic zone for cost-share, endgun controls, and pressure regulators) plus selected objective criteria about the candidate system such as operating pressure, sprinkler type, flow meter, etc., along with more subjective criteria such as irrigation hardware quality, farmer comfort level with technology, power savings potential, yield improvement potential, etc. A cost/benefit section was included to weigh cost of VRI vs. acres removed from irrigation (non-cropped areas) and acres with 50% (or less) water application.

The required items were simply yes/no response questions. Any “no” response would essentially preclude that center pivot from being considered for cost-share assistance for VRI. The remaining items each assigned a point value and the sum of these points became the Index value for that center pivot. NRCS used the Index value to rank systems as funds were limited and thus only a select few pivots (highest ranking) would receive cost-share assistance for VRI.

In the example values shown in Table 1, a relatively small center pivot (26 ac) is included that had 39 spray on drop nozzles and VRI would allow 2.7 acres to not be irrigated and 3.8 acres to receive 50% or less irrigation. The Index value for this system was 185. Continuing this example, if all other criteria were the same but the pivot was larger (72 ac) requiring more nozzles and an additional node (VRI cost $18000) but allowed 10 acres to not be irrigated and 15 acres to receive 50% or less irrigation, then the water savings points would increase to 264 and the Suitability Index would increase to 366. Thus, in these two examples, the larger pivot would be ranked/rated higher than the smaller pivot due to the water savings potential of the larger system when fitted with VRI.

However, the VRI Suitability Index could potentially be enhanced to better address overall field variability. While the ‘water savings’ section takes into account non-cropped areas and areas requiring less than 50% irrigation water, the overall variability in the field being irrigated is currently not a criterion in the index. As discussed earlier, this field-scale variability could be due to other factors such as changes in soil type and texture, moisture holding capacity, and slope. Additionally, for this project, other criteria would enhance the usefulness of the Index. These criteria could include water source (surface vs. ground water), flow rate of the pivot, age of the pivot, proximity to Flint River or tributary stream, a weighting factor tied to geographic location (county or watershed), a stronger factor related to endgun control, and a factor for recognizing the benefits of incorporating other on-farm water conservation measures (irrigation scheduling, soil moisture sensors, conservation tillage, etc.).

Table 1. VRI suitability index with example values (in italics).

Item	Metric	Value
Requirements	Yes/No	
Electric power supply (vs. hydraulic drive)		*Yes*
Within geographic boundaries		*Yes*
Endgun controls (if present & to be controlled)		*Yes*
Pressure regulators installed		*Yes*
Prerequisites	1-10 points	
System pressure	10 psi = 10, 80 psi = 1	*5*
Pump operating ‘curve’	Flat = 10, Steep = 1	*8*
System hardware quality	Excellent = 10, Poor = 1	*9*
Sprinkler type	Spray/drop = 10, Spray/top = 5, Impact = 1	*10*
Pressure regulators	Installed = 10, Not = 1	*10*
Electrical power source	Power Co. = 10, Generator = 5	*10*
Desirables	1-10 points	
Flow meter installed	Yes = 10, No = 1	*10*
Farmer technology comfort level	High = 10, Low = 1	*6*
Personal Computer ownership	Yes = 10, Not = 5	*10*
Amount of field information	High = 10, Low = 1	*4*
Willingness to adopt innovative cultural practices (e.g. conservation tillage system with cover crops)	Yes = 10, Not = 1	*10*
Cost/Benefit		
VRI System cost		
$10,300 + $1,700/ node + $34/nozzle valve	*$15000*	
Water savings		
Acres removed from irrigation	*2.7*	
Acres with 50% (or less) reduced irrigation rate	*3.8*	
Water savings points[#]		*83*

Power savings potential	Low = 1, Medium = 5, High = 10	*5*
Yield improvement potential	Low = 1, Medium = 5, High = 10	*5*
Total Score		***185***

[#]Water savings points = [(Acres removed from irrigation + 0.5 x Acres with 50% or less reduced irrigation) / 271540] / (VRI system cost), where 271540 is gallons from avg of 10 acre-inches applied.

Final Report

MAINTAINING OPTIMAL SOIL MOISTURE IN PEANUTS WITH VARIABLE-RATE IRRIGATION

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University of Georgia, Bio & Ag Engineering - Tifton

Michael Dukes
University of Florida, Bio & Ag Engineering

Introduction

In Georgia and Florida, there are over 400,000 acres of irrigated peanuts grown, with the majority being irrigated by center pivot systems. In the peanut growing regions of the two states, considerable field variability exists in the forms of sub-field zones of varying soil types and textures, topography, multiple crops grown under a pivot, crop maturity levels, etc. When conventional irrigation is used, the relatively uniform application of water may cause many of these zones to receive too little water while other areas become over-watered. Often, irrigation systems apply water to non-cropped areas (roads, grassed waterways, wetlands, etc.).

Variable-Rate Irrigation (VRI), a new irrigation control technology developed by The University of Georgia Precision Ag Team, can differentially apply center pivot irrigation water to match the precise needs of individual sub-field zones, thereby not over- or under-watering certain areas or applying water to non-cropped areas. Application rates are varied by a combination of pivot speed control and by cycling sprinklers on/off. In the fall of 2004, VRI became commercialized and has been installed on 30+ center pivot systems through Hobbs and Holder, LLC.

One of the premises for development of VRI was that by matching the actual soil water holding capacity with appropriate amounts of irrigation water, optimal soil moisture would be maintained, thereby enhancing crop growth and yield. Another benefit of VRI controls is the potential for water conservation when compared to conventional application.

The objectives of this research proposal were to: a) determine if VRI controls can enable a center pivot to maintain optimal soil moisture for peanut production; and b) determine if, by maintaining optimal soil moisture, peanut yield and quality will be significantly enhanced.

Procedure

Two fields in Georgia were selected to participate in the 2006 VRI peanut study. One was located in Pulaski Co. ("RD") and one located in Turner Co. ("DJ"). Both fields already had center pivot (CP) irrigation systems fitted with Variable-Rate Irrigation (VRI) controls and were planted with peanuts for the 2006 growing season. Farmers were told to follow their normal farming operations including their watering schedules. Background data was obtained for each field including field boundary, bare soil imagery, Veris soil EC (shallow and deep), topography, soil types, and VRI water application prescription map.

Management zones were delineated using Veris soil EC and the Management Zone Analyst software from USDA-ARS (Columbia MO) as well as soil type and topography data. Two major soil zones were selected. Within these two zones, three paired treatment replicates were established to compare irrigated with VRI vs. irrigated conventionally for a total of 12 sampling areas. These replicates were each comprised of 4-6 VRI irrigation control zones, depending on the size of particular zones.

Within each replicate, a site was selected for soil moisture sensors. ECH20 probes were installed at 2 in and 12 in depths and connected to a Hobo micro-station for data logging. The Hobo micro-stations were used to store data collected on a specified interval (4 hours) and were placed as close to the sensors as possible to reduce the amount of exposed wire from the sensors to the micro-stations. The micro-stations were located on a post approximately 18 inches above the soil surface to keep them off the moist soil. The exposed wires were covered as best possible with flexible tubing. Careful placement of these datalogging stations ensured that they would not alter or impede the farms' normal field operations. Two raingages were placed at each farm, one outside the CP coverage area and one within the CP coverage area. Soil moisture and rainfall/irrigation data were to be logged throughout the growing season.

In the fall, after the peanuts were inverted, three 10 ft sections of windrowed peanuts/vines were removed from each replicate area. Peanuts were removed from the vines by using a manual thresher then weighed. Moisture content of a sub-sample of kernels was measured immediately after weighing. Another sub-sample of peanuts was sent to the Federal-State Inspection Service for grade determination.

Results and Discussion

As this was the first year using the Echo soil moisture sensors, the researchers encountered some unexpected problems with the devices. These problems ranged from rodents chewing any exposed wiring, the devices requiring more monitoring than implied (unexpected and unexplained loss of power or invalid data readings), and the probes needing calibration for "Georgia" soils despite the manufacturers recommendations that calibration was not needed. These problems left gaps in the soil moisture data throughout the growing season and also diminished the confidence level in some of the sites (i.e., those with unexplained, self-corrected data anomalies). However, even with the inconsistent nature of the data collected, we were still able to decipher some usable information and trends.

Figures 1 through 5 are of the "DJ" field and show the data sampling points along with bare soil, Veris EC (deep), topo, soil types, and VRI application map, respectively. Based on the farmer's knowledge of the field, its topography, and previous yields, the farmer chose to apply a 120% rate in the region where sampling points A, B and C were located, and chose 80% rate in the region where points D, E, and F were located. For this study, the comparison irrigation rates would be the farmer's VRI rates, designated as the number 1 plot in each zone, vs. 100% (conventional), designated as the number 2 plot in each zone, rates.

Table 1 lists the irrigation zones, apparent soil texture (from EC data), and elevation at the sampling point in the zone, total water applied to the zone as well as yield and grade for the "DJ" field. The total water applied only varied by 0.5 inch due to the farmer only applying 4.5 inches (100%) irrigation as the field received 8.93 inches of rainfall.

The yields in the "DJ" field were quite high, overall, but varied from zone to zone. Grades were average for all test zones, with SMK values ranging from 73 to 75. In zones A, B, and C where the farmer's VRI zones were 120% irrigation (120% of normal), yields were greater for VRI at points A1 and B1 but slightly lower for VRI zone at point C1. Thus at 2 of the 3 test locations where the farmer selected a VRI rate requiring "extra" water compared to conventional (120%), the choice appeared to be the right one as it was supported by soil and yield data/results. The higher yield for conventional at point C2 could be due to the soil at point C2 having less sand/more clay than point C1 (Fig 2) and thereby having a greater water holding capacity. This was seen in the limited soil moisture data collected at C1/C2 where the shallow soil moisture readings were similar but C2 deep readings were considerably higher than C1. This could indicate that a) the irrigation zone surrounding point C1 may need adjusting to a rate higher than even 120% and b) the zone surrounding point C2 may need to be adjusted to 100% instead of 120%.

In zones D1, E1, and F1 where the farmer selected his VRI rate to be 80% of normal, the only location where VRI yielded greater than conventional was VRI at point D1. This could indicate that the farmer's selection of 80% irrigation for E and F points was not providing enough soil moisture for optimal growth. As points D1 and D2 were at the bottom of a considerable slope (Fig 3) where the terrain begins to flatten, the down-slope movement of water likely provided ample soil moisture in the 80% zone there and may have over-watered zone D2 (100% zone). The soil moisture data that was obtained from D1 and D2 suggested that the deep soil moisture reading was considerably higher at D2 than D1.

Table 1. "DJ" field parameters. % Irrigation refers to farmer's VRI water application rate. Soil texture was determined from Veris EC data. Elevation was determined from RTK-GPS data. Total water includes irrigation and rainfall.

Zone	% Irrigation	Soil Texture	Elevation (ft)	Total Water (in)	Average Yield (lbs/ac)	Average Grade (SMK)
A1	120	Very sandy	380.25	13.9	5121.49	73
A2	100	Moderately sandy	380.58	13.4	4500.06	74
B1	120	More clay	385.50	13.9	5985.82	75
B2	100	Moderately sandy	384.19	13.4	5170.75	75
C1	120	Very sandy	378.94	13.9	4837.37	75
C2	100	More clay	384.84	13.4	5194.20	74
D1	80	Very sandy	366.14	12.9	4744.27	75
D2	100	Very sandy	365.49	13.4	4530.05	75
E1	80	More clay	372.70	12.9	4695.11	73
E2	100	Moderately sandy	371.72	13.4	5104.87	74
F1	80	More clay	378.28	12.9	4676.30	74
F2	100	More clay	377.95	13.4	4730.52	74

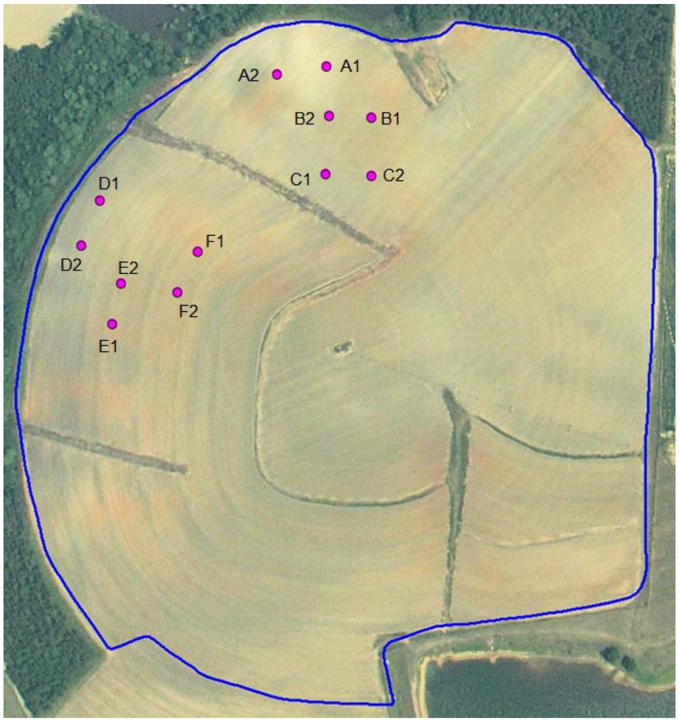

Figure 1. Bare soil aerial image of "DJ" field with sampling points overlaid.

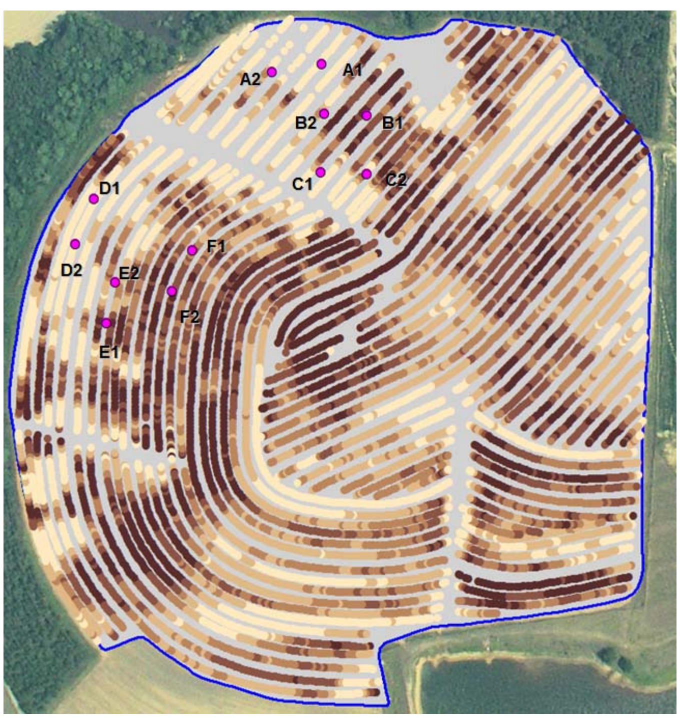

Figure 2. Veris EC data for "DJ" field. Lighter colors represent lower EC values and higher sand content.

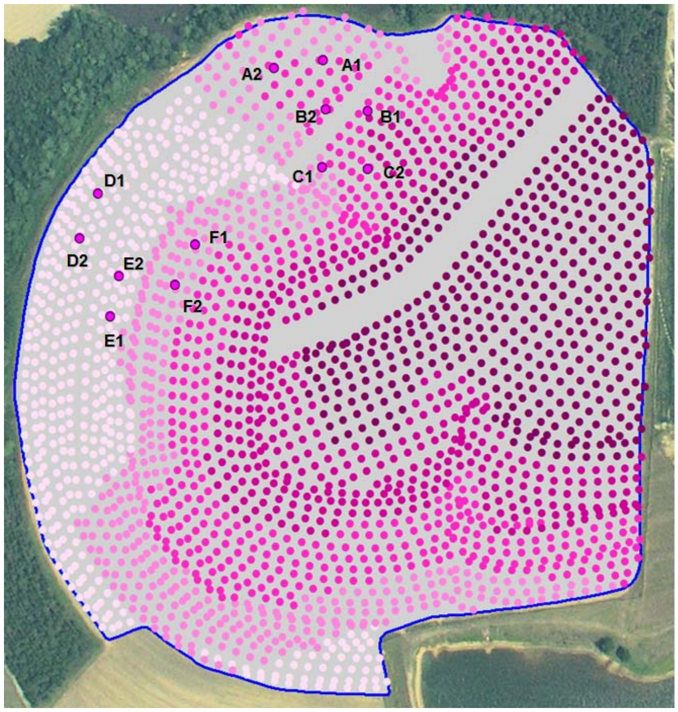

Figure 3. Topographic data collected in the "DJ" field. Lighter colors represent lower elevations.

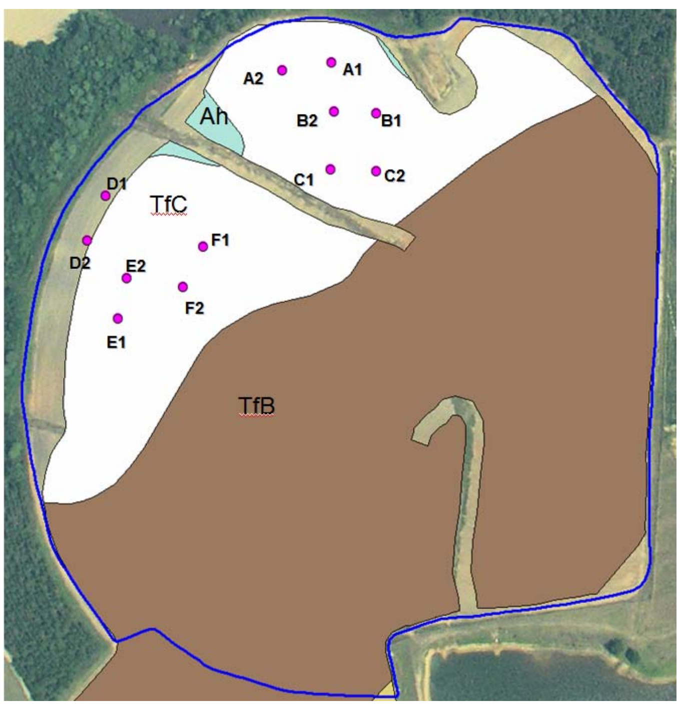

Figure 4. Major soil types in the "DJ" field.

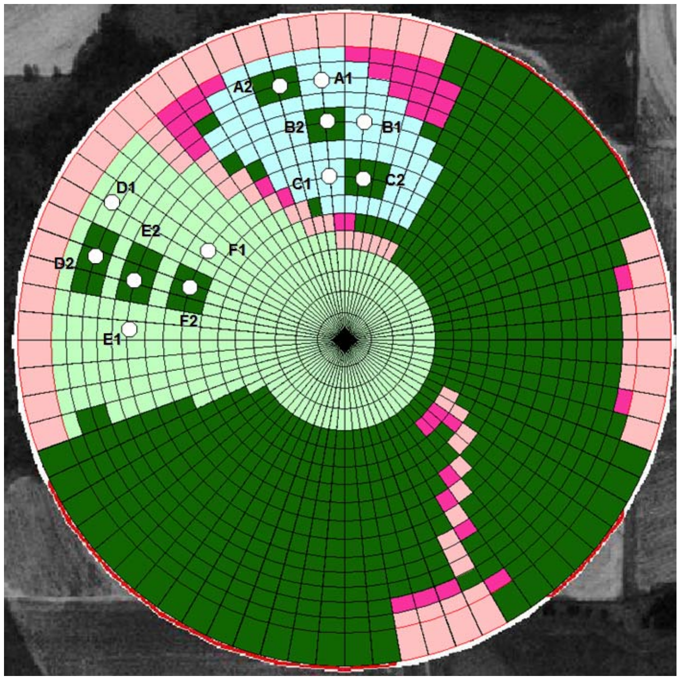

Figure 5. VRI irrigation application map for "DJ" field.

Figures 6 through 10 provide information on the "RD" field and, again, show the data sampling points along with bare soil, Veris EC (deep), topo, soil types, and VRI application map, respectively. Based on this farmer's knowledge of the field, its topography, and previous yields, he chose to apply a 70% rate in the region where sampling points A1/A2, B1/B2, and C1/C2 were located, and chose 100% rate in the region where points D1/D2, E1/E2, and F1/F2 were located. For this study, the comparison irrigation rates would be farmer's VRI rates (70%) vs. 100% (conventional) for points A1, B1, and C1, and farmer's 100% rates vs. VRI (80%) (selected by the researchers) for points D1, E1, and F1.

As in the "DJ" field, soil moisture data was inconsistent and raingage data was never successfully stored. However, a University-owned weather station was located a few miles from the site. Table 1 lists the irrigation zones, apparent soil texture (from EC data), and elevation at the sampling point in the zone, total water applied to the zone as well as yield and grade for the "RD" field. The total water applied varied by a maximum of 2.25 inches due to the farmer applying 7.5 inches irrigation as the field received 12.5 inches of rainfall.

The yields in the "RD" field were above average, overall, and varied from zone to zone. Grades were above average to high for all test zones, with SMK values ranging from 76 to 78. In zones A1, B1, and C1 where the farmer's VRI zones were 70% irrigation (70% of normal), yields were lower for VRI at points A1 and B1 and the same as conventional at point C1. Thus at 2 of the 3 test locations where the farmer selected a VRI rate requiring "less" water compared to conventional (70%), the choice appeared to not be the best one as yields were the same or lower.

The apparent need for greater soil moisture, as evidenced by the higher yields from the 100% zones at A2 and B2 vs. the lower yields found in VRI (70%) zones A1 and B1, is likely due to the deep sand found in those two sampling locations (Fig 7). The six points at A, B, and C are at the bottom of a long, gradual slope (Fig 8) (29 ft change in elevation) with erosion deposits likely contributing the high sand content. Points C1 and C2, while in the farmer's 70% VRI zone, are in "heavier" soils with less sand/more clay (Fig 7) and thus have a higher water holding capacity. The limited soil moisture data from these two locations showed that at C1 the deep soil moisture readings were higher. The data would suggest that the farmer should consider adjusting the VRI zone to increase water application in the A and B zones and leave the C zone as-is.

In zones D1/D2, E1/E2, and F1/F2 where the farmer selected his rate to be 100% (i.e. normal application), the only location where VRI (80%) did not yield greater than conventional was VRI at point F1. Points D1/D2 and E1/E2 were upslope from points F1/F2 and although Figure 7 shows all 6 points to have similar EC values, closer examination of actual EC values show points F1/F2 had lower values, indicating more sandy texture, with F2 having the lowest EC value. This suggests that upslope, in the zones with heavier clay content, the soils held ample soil moisture and required less irrigation, but downslope, in the less-clay zone with lower water holding capacity, additional irrigation was needed. The limited soil moisture data appeared to support this conclusion.

Table 2. "RD" field parameters. % Irrigation refers to farmer's VRI water application rate. Soil texture was determined from Veris EC data. Elevation was determined from RTK-GPS data. Total water includes irrigation and rainfall.

Zone	% Irrigation	Soil Texture	Elevation (ft)	Total Water (in)	Average Yield (lbs/ac)	Average Grade (SMK)
A1	70	Sandy	289.37	17.75	3521.03	76
A2	100	Sandy	290.35	20.00	3956.33	76
B1	70	Moderately sandy	292.65	17.75	3306.48	77
B2	100	Moderately sandy	291.99	20.00	3572.53	76
C1	70	More clay	289.70	17.75	4302.78	76
C2	100	More clay	290.35	20.00	4304.48	77
D1	80	More clay	307.09	18.00	3613.96	78
D2	100	More clay	309.71	20.00	3521.17	78
E1	80	More clay	304.79	18.00	4080.20	78
E2	100	More clay	302.82	20.00	3910.80	76
F1	80	Less clay/More sand	295.93	18.00	3306.37	77
F2	100	Moderately sandy	296.92	20.00	3682.24	76

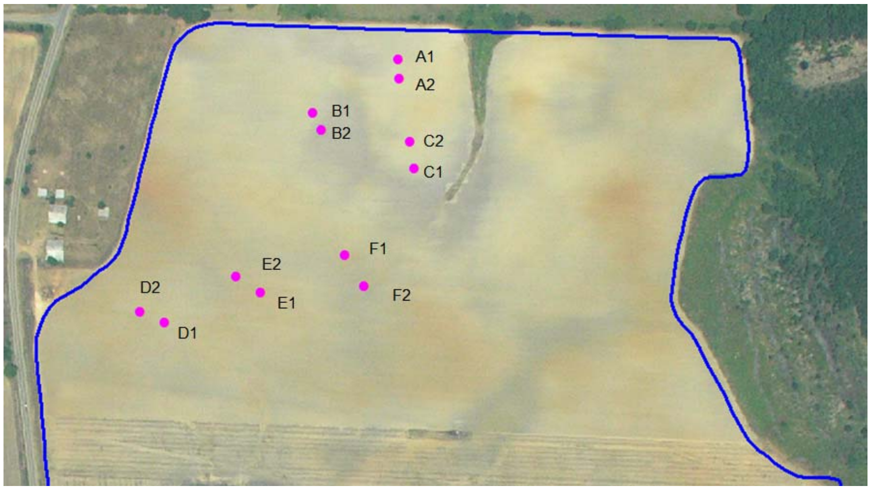

Figure 6. Bare soil aerial image of "RD" field with sampling points overlaid.

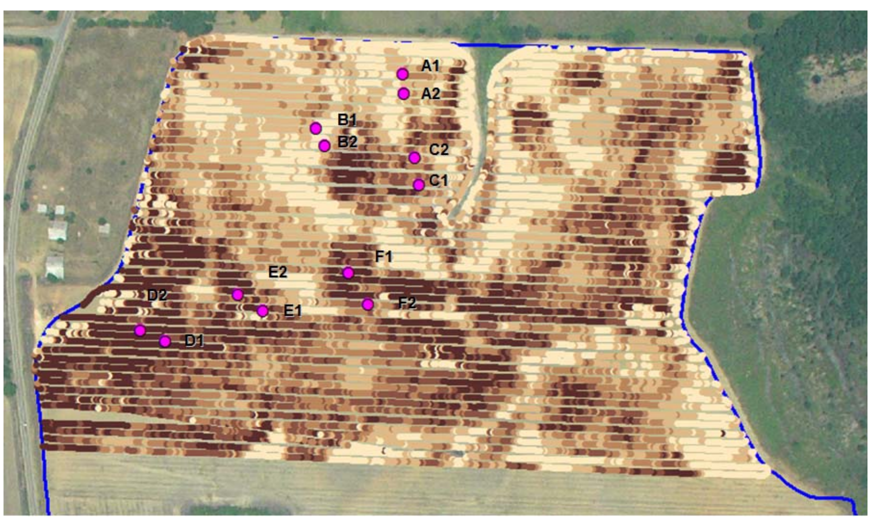

Figure 7. Veris EC data for "RD" field. Lighter colors represent lower EC values and higher sand content.

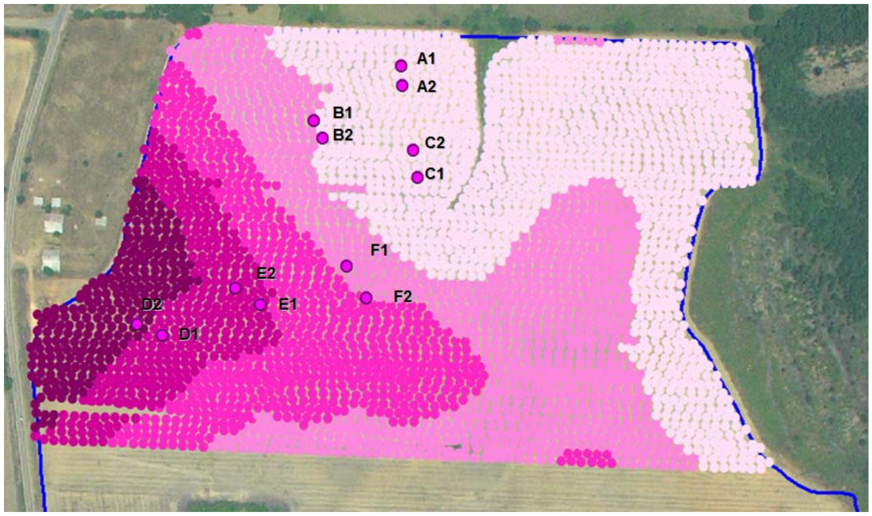

Figure 8. Topographic data collected in the "RD" field. Lighter colors represent lower elevations.

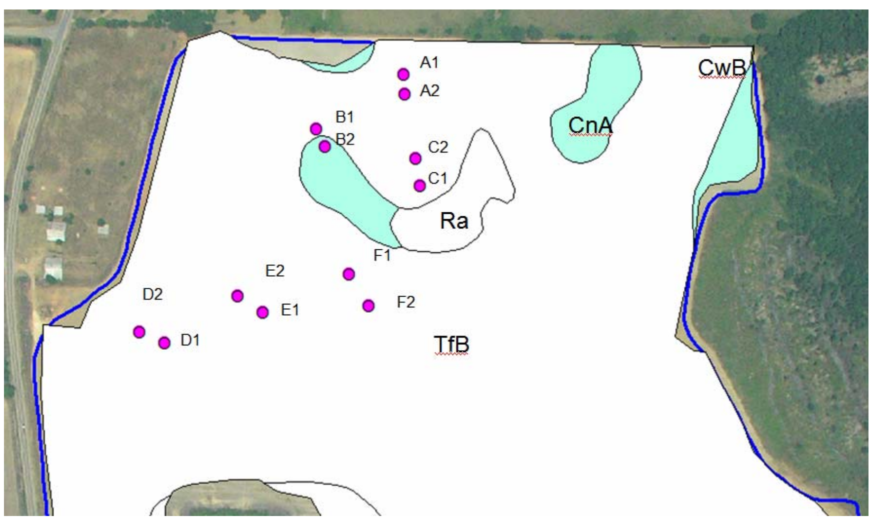

Figure 9. Major soil types in the "RD" field.

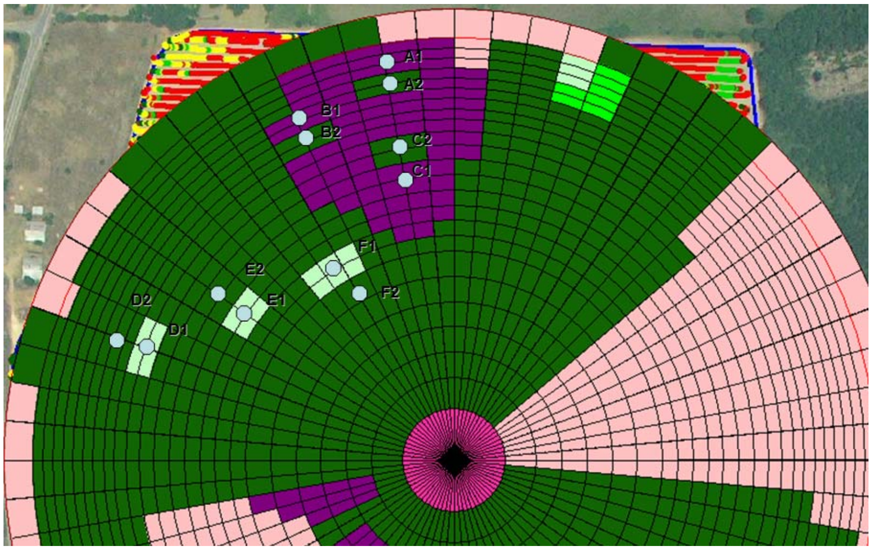

Figure 10. VRI irrigation application map for "RD" field.

Conclusions

The lack of a complete, season-long data set for soil moisture and raingage readings makes it difficult to definitively prove that VRI controls can maintain "optimal" soil moisture for peanut production. However, the limited amount of data collected in conjunction with the yield/grade data does allow for limited conclusions to be drawn.

Location in the landscape (upslope, sideslope, downslope, etc.) to have an impact on soil moisture. These data suggest that the soil texture and water holding capacity should be more heavily considered when farmer's set their water application rates. Depending on location, simply applying more irrigation does not always result in increased yields. For example, in both the "DJ" and "RD" fields, there were some zones that yielded higher with less water applied. In some of the zones, the growers' VRI water application rates did not appear to be at an optimal amount. The data suggest that by adjusting the water application rates to better match soil texture and water holding capacity these optimal levels can be reached.

The ECH20 soil moisture sensors were fairly easy to install and connect to the dataloggers, but they appear to need calibration for "Georgia" soils despite the manufacturer's recommendation that calibration is not necessary. The experiences learned in this project shows that dataloggers should be checked more frequently than the manufacture implies as both technical and mechanical problems can occur unexpectedly. A current project is looking at the use and calibration of these sensors to make them more useful in these types of field research settings.

Variable-Rate Irrigation (VRI) controls offer the ability to tailor water application in specific zones in fields. However, much thought and planning must go into selecting appropriate rates in the zones. This study suggests that although farmers' instincts are often correct about irrigation management zones, often times their yields can be enhanced when factoring in further soils data.